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NEWS AND REVIEWS

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THE RELATION OF PHYSICAL PROPERTIES AND CHEMICAL COMPOSITION TO MEALINESS IN THE POTATO. I. PHYSICAL PROPERTIES[1]

A. M. Unrau[2] and R. E. Nylund[3]

Introduction and Literature Review

Mealiness and whiteness are cooking qualities of potatoes generally considered most desirable by household and institution buyers (3). Of these two physical characteristics, mealiness is most important except in cases where discoloration during cooking is encountered.

A number of measurable factors are apparently correlated with mealiness. Among these, a positive correlation between specific gravity and mealiness has been generally demonstrateed. In an extensive review of the literature, Sweetman (8) indicated that some exceptions to this correlation had been encountered and that an explanation based on chemical composition was not available for the non-correlating cases. Kirkpatrick *et al.* (5) found no significant correlation between specific gravity and mealiness in four varieties of early crop potatoes. Haddock and Blood (2) showed that potatoes of identical specific gravity, but grown at different locations, differed in mealiness. Greenwood *et al.* (1) also demonstrated that the association between specific gravity and mealiness varied depending on the location where the potatoes were grown. Nylund and Poivan (6) showed that potatoes of identical specific gravity varies in mealiness depending on the date of planting and on variety.

Experiments were conducted to relate, if possible, variations in mealiness to physical properties and chemical composition of potatoes. This paper is a report on experiments concerned with the relationship between mealiness and some physical properties of raw and boiled tissue. Experiments concerned with chemical composition are described elsewhere in this journal.

Materials and Methods

The potatoes used in the experiments were grown in 1953 and 1954 under similar environmental conditions and cultural practices at the Red River Valley Potato Research Laboratory (U.S.D.A.), East Grand Forks, Minnesota. The tubers were harvested on the same day and stored at 36-40° F. until used. The tubers from storage were conditioned for fourteen days at 69-70° F. prior to their use in organoleptic tests and other physical tests. Tubers were separated into specific gravity groups by the usual salt brine flotation method.

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Paper No. 3745 of the Scientific Journal Series of the Minnesota Agricultural Experiment Station, St. Paul, Minn.
[2]Formerly Research Assistant, Department of Horticulture; at present Research Assistant, Department of Biochemistry.
[3]Associate Professor, Department of Horticulture.

Organoleptic Tests;

While previous tests at the University of Minnesota (6) had shown that potatoes differing in variety and/or specific gravity differed in cooking quality, these tests were repeated to determine if similar differences existed between the tuber lots to be used in subsequent experiments. In 1953, tubers of the varieties Cobbler and Red Pontiac and in 1954, tubers of these and a third variety, Waseca, were tested organoleptically. Two distinctly different specific gravity tuber groups (1.080 and 1.100) of each variety were used in the tests.

Tubers for organoleptic evaluation were peeled, boiled until soft throughout, and mashed with an electric food mixer. A taste panel, usually consisting of seven judges, evaluated the various samples of mashed potatoes primarily for mealiness although some attention was also directed to color and flavor.

In 1953, a triangle test was used in which the judges were requested to select the "different" sample from the three samples placed before them, two of the samples being identical. The usual triangle test was modified to allow a judge to indicate "no difference" if no difference between the samples could be detected. The data obtained were analyzed by using a Chi-square test for goodness of fit to a 1:1:1:3 ratio. The triangle design of the above type is useful to determine if differences in a certain characteristic are great enough to be detected by a taste panel.

In 1954, the varieties Red Pontiac, Cobbler and Waseca were evaluated for mealiness by a taste panel using a replicated randomized block design in which six samples were judged at each panel session. Organoleptic tests of this type can be adapted to yield preference data. Each sample was given a numerical score on a scale ranging from 1 (very pasty, non-mealy) to 10 (very mealy). The six tuber lots (2 specific gravity groups from each of 3 varieties) were judged eight times. In order to obtain scores on a comparable basis, a standard sample (Waseca—specific gravity 1.100) was prepared and included in each replication. On the basis of preliminary tests, this standard sample was given a mealiness score of 8 and the judges were informed of this score at each session.

Shear Test Measurements;

An attempt was made to measure the degree of mealiness of the different tuber lots using a simple mechanical device. Such a device, if it furnished reasonably dependable and reproducible results, would eliminate lengthy organoleptic tests which are by no means completely reliable. A possible measure of degree of mealiness is the ease of "cutting" or shearing through a mass of boiled tissue. A mash which is light and mealy offers less resistance to shear than a mash which is heavy and pasty or sticky. The resistance to shear was measured indirectly with an A.C wattmeter installed between the electric power source and the food mixer. Resistance to shear (whipping) was recorded as the difference between the average line load readings obtained during whipping of the potato sample and the base wattage rate obtained by allowing the mixer to run empty until the watt rate became constant. During resistance measurements, the mixer blades were kept in relatively full and continuous contact with the sample. A constant weight of material consisting of at least six tubers was used in

each run and shear data were obtained for eight replications of each tuber lot.

Microscopic or Histological Studies:

Microscopic studies of certain morphological characteristics of raw and boiled potato tissue were conducted to determine if the various tuber lots differed significantly in these characteristics. Starch granule size, cell size, and number of starch granules per cubic millimeter of raw tissue were estimated using a micrometer scale or camera lucida drawings. Starch granule size was estimated using tissue which had been macerated to release the granules. The macerates were made from plugs cut with a cork borer through the greatest diameter of at least 6 tubers. These plugs were then diced and crushed in a mortar and the resulting macerates examined microscopically before excessive browning occurred. Cell size and number of starch granules per cell were obtained by cutting thin sections from various parts of the raw tubers, staining with a dilute iodine-potassium iodide solution, and observing undamaged cells.

The extent of flocculation or aggregation of solids in tissue slurries heated to boiling for 2 minutes and then rapidly cooled was observed microscopically as was the diffuseness of the iodine-stained aggregates. Samples which showed pronounced aggregation of solids into large, compact bodies were scored near 10 while those having a preponderance of small, less defined aggregates were given a lower numerical score. The degree of diffuseness of iodine-stained aggregates was estimated in a similar manner. Stained aggregates which exhibited sharp, well defined boundaries were scored near 10, whereas aggregates surrounded by lightly stained, diffuse halos were scored lower. In the same slurries, the number of starch granules which still retained their shape (apparently intact) were also recorded.

Viscosity Measurements with the Brabender Amylograph:

The Brabender Amylograph is useful in studying the swelling properties of various starchy materials. The changes in viscosity of suspensions heated at a constant rate are automatically recorded as are also the time and temperature necessary to reach maximum viscosity.

For the amylograph studies, conditioned tubers selected at random were peeled thinly and then diced. The diced material was rinsed to remove free starch using a 0.5 per cent solution of sodium bisulphite to prevent excessive surface oxidation. The raw product was then frozen at -10° C., crushed in an ice crusher and dried in a large lyophilizer. The dried material was pulverized in a Wiley mill to pass through a 40 mesh screen. Test runs indicated that 30 grams of dry material suspended in 400 mls of distilled water produced the most desirable amylograph curves. The suspensions were heated in the apparatus at a constant temperature increase of 1.5°C. per minute to a maximum temperature of 89-90°C. where maximum viscosities were reached and the thinning process set in.

Results and Discussion

Organoleptic Tests:

The data obtained in the 1953 organoleptic tests using the modified triangle test previously described are shown in table 1. The distribution of choices in Group A shows that the taste panel had no difficulty in selecting

TABLE 1.—*Distribution of taste panel choices for mealiness within each of four samples in which either specific gravity or variety was the only variable.*

Group	Variety and Specific Gravity		Choice Distribution
A	Red Pontiac	1.100	26
	Red Pontiac	1.080	1
	Red Pontiac	1.080	1
	"No difference"		0
		X^2	116**
B	Cobbler	1.080	29
	Cobbler	1.100	0
	Cobbler	1.100	1
	"No difference"		4
		X^2	107**
C	Red Pontiac	1.100	19
	Cobbler	1.100	4
	Cobbler	1.100	2
	"No difference"		4
		X^2	51**
D	Cobbler	1.080	21
	Red Pontiac	1.080	2
	Red Pontiac	1.080	1
	"No difference"		10
		X^2	50**

**Indicates highly significant deviation from a fit to a 1:1:1:3 ratio.

the sample which differed in mealiness among samples of Red Pontiac of widely different specific gravity. Similar results were obtained when Cobbler tubers were evaluated (Group B). When samples of identical specific gravity, but differing in variety, were judged, the panel again selected one sample as being "different" in mealiness. This is evident in the data in Group C for high specific gravity tubers and in Group D for low specific gravity tubers. The data of the tests establish conclusively that the judges could distinguish differences in mealiness of potatoes varying in variety and/or specific gravity.

Having established the sensitivity of the taste panel, the succeeding organoleptic tests were conducted to determine mealiness preferences. The mean mealiness scores for the six different tuber lots are presented in table 2. The mealiness scores of low and high specific gravity Red Pontiac were not significantly different from each other nor from that of low specific gravity Cobbler. However, low specific gravity Waseca was scored higher in mealiness than the above-mentioned lots. High specific gravity Cobbler and Waseca were rated highest in mealiness and were different from each other.

The 1953 and 1954 organoleptic test data show conclusively that tubers of identical specific gravity can differ considerably in mealiness. These

TABLE 2.—*Mean mealiness scores of six potato lots differing in variety and specific gravity.*

Variety	Specific Gravity	Mean Score
Red Pontiac*	1.080	5.2
Red Pontiac	1.100	4.9
Cobbler	1.080	5.4
Cobbler	1.100	7.9
Waseca	1.080	6.2
Waseca	1.100	8.0
L.S.D., 5 per cent level		0.8
L.S.D., 1 per cent level		1.1

*In limited tests Red Pontiac having a specific gravity of 1.065 was compared to the above tuber lots and a mealiness score for these tubers of 3.0 was obtained.

results are in agreement with those of Nylund and Poivan (6) and others (2).

Objective Methods of Measuring Mealiness:

Because organoleptic tests are time consuming, require large quantities of material, and require the service of many people whose ability to evaluate may vary from day to day, an objective method for measuring mealiness would be desirable. In the course of mashing boiled tubers for subsequent taste panel evaluation, it was noticed that some of the samples became very sticky and pasty, whereas others remained fluffy and light in texture. The resistance to whipping or shear appeared to be much greater for the pasty samples than for the mealy types. This difference was measured by a simple device described previously. The results of this shear-test are given in table 3 together with respective mealiness scores. A highly significant correlation of -0.92 was obtained between mealiness scores and the amount of electrical energy (line load increase) necessary to shear the mash. On the basis of these results, this type of measurement appears potentially useful for objective evaluation of mealiness of potatoes. An apparatus in which temperature could be accurately controlled would undoubtedly reduce the variation encountered between replicate determinations.

Physical Characteristics Related to Mealiness:

The data obtained in the various physical tests on raw and heat-treated tissue of each of the tuber lots are presented in table 4 together with respective mealiness scores. No association between starch granule size and mealiness is evident. This does not agree with a recently reported observation by Shewfelt, *et al.* (7) and earlier reports that differences in the relative ease of gelatinization can be related to the size of starch granules (4). The data for degree of flocculation of solids, diffuseness of iodine-stained aggregates, and number of apparently intact starch granules indicate some degree of association between these characteristics and mealiness. The heat-treated tissue slurries from high specific gravity Cobbler and Waseca

TABLE 3.—*Resistance to shear (whipping) of boiled tubers as measured by the line load increase over a base rate of the electric food mixer.*

Variety	Specific Gravity	Mealiness Score	Line Load Increase (Watts)
Red Pontiac	1.080	5.2	41.1
Red Pontiac	1.100	4.9	44.3
Cobbler	1.080	5.4	35.7
Cobbler	1.100	7.9	22.4
Waseca	1.080	6.2	35.4
Waseca	1.100	8.0	26.1
L.S.D., 5 per cent level			3.7
L.S.D., 1 per cent level			5.0
"r" With mealiness			-.92**

TABLE 4.—*Physical characteristics of potato tissue in relation to mealiness of seven different tuber lots.*

Variety and Spec. Gravity	Mealiness Score	St. Gran. 0.2 m.m. Dia. and over	Ave. Diam. Starch Gran.	Degree of Flocc.	Diffus. of Aggreg	Intact Gran. per Mic. Field
Red Pontiac		Per cent	Mm.			No.
1.065	3.0	--	--	3	2	7.5
1.080	5.2	25	.12	6	5	5.4
1.100	4.9	21	.14	5	4	10.8
Cobbler						
1.080	5.4	19	.11	9	9	0.8
1.100	7.9	26	.14	10	10	0.0
Waseca						
1.080	6.2	16	.10	8	7	2.2
1.100	8.0	14	.17	9	8	0.5
"r" with mealiness		-.49	.62	.78*	.83*	-.75

tubers exhibited greater flocculation of solids, a lesser degree of diffuseness of the iodine-stained aggregates, and fewer apparently intact starch granules than the low specific gravity samples of the same varieties. In the Red Pontiac lots, all of which were low in mealiness, less flocculation of solids was evident, aggregates were more diffuse, and a greater number of intact starch granules were present. Although some association is evident between these physical characteristics and mealiness, it is apparent from examination of mealiness scores of low specific gravity Cobbler and all the Red Pontiac samples that the differences in mealiness cannot be completely explained on the basis of differences in the above physical characteristics.

The results obtained in the viscosity measurements using the Brabender Amylograph are presented in table 5 and the curves are shown in figure 1. Among the high specific gravity samples, Cobbler and Waseca exhibited

TABLE 5.—*The relative viscosity of suspensions of lyophilized tissue when gelatinized in a Brabender amylograph.*

Variety and Spec. Gravity	Mealiness Score	Maximum Visc.*	Temperature at Maximum Viscosity	Time to Maximum Viscosity
			°C.	
Red Pontiac				
1.065	3.0	315	91	64
1.080	5.2	460	85	60
1.100	4.9	515	88	62
Cobbler				
1.080	5.4	460	85	60
1.100	7.9	665	76	54
Waseca				
1.080	6.4	490	88	62
1.100	8.0	630	79	56

.95**

*In relative numerical Amylograph units.

similar viscosity curves but the Red Pontiac samples gelatinized more slowly and did not attain as high a maximum. The rate of gelatinization of the low specific gravity samples were similar, Waseca showing a slightly higher maximum viscosity than did Cobbler and Red Pontiac. This same lot of Waseca tubers also scored higher in mealiness than did the comparable tuber lots of Cobbler and Red Pontiac. The correlation between maximum relative viscosity and mealiness is .95 (Table 5). This physical measurement has the advantage over the shear test that was used in that accurate temperature control is maintained, the starting material is more homogeneous, and conditions can be easily varied or manipulated. Few biochemical and physiological changes occur during lyophilization so that, in effect, the measurements are made on material differing from fresh tissue only in moisture content. The chief drawbacks to this method for evaluating mealiness are the length of time involved until results are known and the cost of the freeze-drying and amylograph apparatus. However, where such equipment is available, amylograph studies would undoubtedly yield some valuable information.

SUMMARY

1. Organoleptic tests conducted on two varieties of potatoes in 1953 and on three varieties in 1954 confirmed previous observations that:
   (a) potatoes within a variety which differ in specific gravity differ in mealiness, and
   (b) potatoes of different varieties but identical in specific gravity may also differ in mealiness depending on the varieties being compared.
2. Physical characteristics which appear to be associated with mealiness are:
   (a) the degree of flocculation of solids in tissue slurries which had been heated and then allowed to cool,

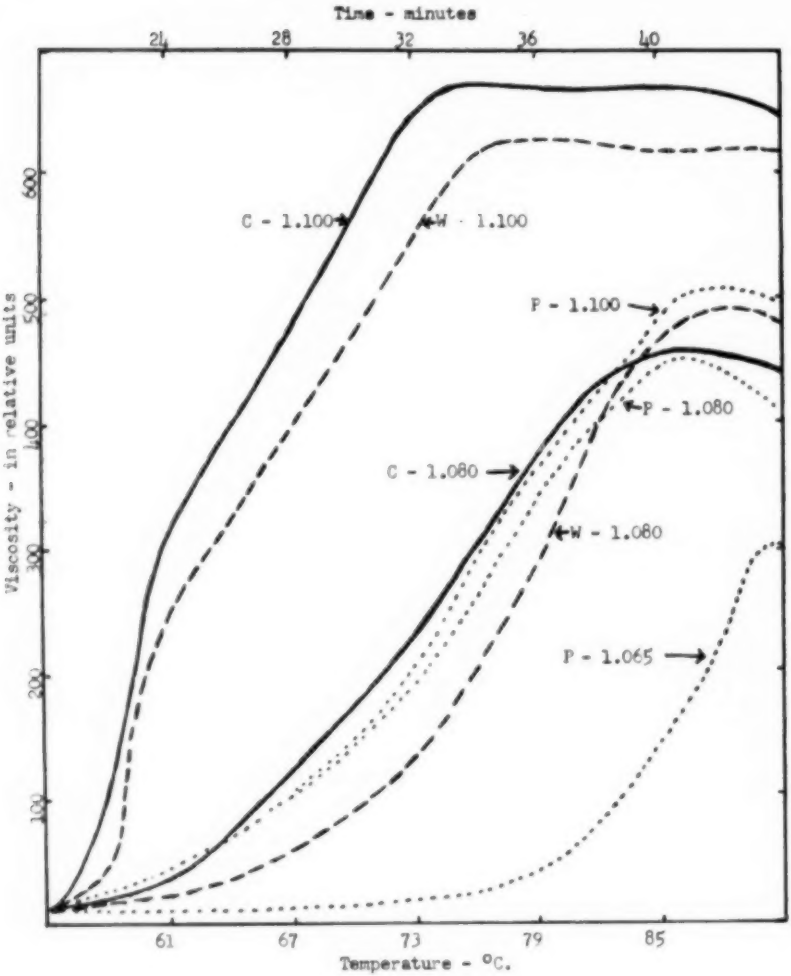

FIGURE 1.— The Amylograph viscosity curves of tissue suspensions of seven different tuber lots.
C - Cobbler ——————
W - Waseca - - - - - - - -
P - Red Pontiac .....

(b) the degree of diffuseness of aggregates as determined by observation of iodine-KI stained material.
(c) the number of apparently intact starch granules in heat-treated tissue slurries,
(d) the resistance to shear or whipping of boiled tubers, and
(e) the maximum relative viscosity of suspensions of lyophilized tissue when gelatinized in a Brabender Amylograph.

3. The size of starch granules in raw tubers is apparently not associated with mealiness in potatoes.

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SPROUTING, PLANT GROWTH, AND TUBER PRODUCTION AS AFFECTED BY CHEMICAL TREATMENT OF WHITE POTATO SEED PIECES[1]

I. Breaking the Rest Period with Gibberellic Acid

Lawrence Rappaport, L. F. Lippert and Herman Timm[2]

The year-round production of potatoes in California frequently necessitates the use of relatively immature, resting[3] tubers as seed. To assure uniformity of sprouting and maximum stands of potatoes, chemicals such as ethylene chlorohydrin, thiourea, and potassium thiocyanate (5, 6, 12) have been employed to break the rest period. The most important of these, ethylene chlorohydrin, however, is no longer available for this purpose and a substitute is needed. It has been suggested that gibberellins may break rest in potatoes (3, 10). This paper describes more definitely the sprouting behavior of potatoes after treatment with gibberellic acid (GA).

General Procedures

To assure the use of potatoes in the rest period all tuber samples were harvested when the foliage was still green (6). White Rose, Kennebec, or Russet Burbank potatoes were sorted for uniformity, washed, and dipped for periods of 5 or 90 minutes in water, or in solutions containing 25, 50, 500, or 2000 μg/ml of gibberellic acid[4]. Whole tubers were used in all experiments. After treatment, the tubers were either (a) held in open flats, (b) held in enclosed glass or metal chambers which were supplied continuously with air at constant temperatures of 50°, 59°, or 77°F, or (c) planted in cans of soil or in soil benches and grown in a greenhouse at 65°-70°F.

Experimental

A. *Sprouting in Controlled Temperature Storage:* Tubers of the White Rose variety were dug on August 21, 1956, and divided into two lots of 55 each the following day. One lot was immersed for 90 minutes in a solution of 25 μg/ml GA, and the other in water. The tubers were then placed in flats and stored at 77°F.

The results show that almost all tubers sprouted in 24 days after treatment with GA (Table 1). Sprouts developed at almost every eye of treated tubers, whereas those dipped in water usually produced only a single sprout at an apical eye.

Another experiment evaluated the sprouting response of tubers to higher concentrations and a shorter period of immersion in GA. Certified White Rose seed potatoes dug on November 9 were divided into twelve

[1]Accepted for publication April 18, 1957.
[2]University of California, Department of Vegetable Crops, Davis, Calif.
[3]Rest is defined as that period immediately following harvest during which the potato tuber will not sprout even under optimal sprouting conditions (6, 13).
[4]Gibberellic acid was generously provided by Merck, Sharpe and Dohme, Inc. and Eli Lilly and Co.

TABLE 1.—*Sprouting percentage of White Rose potatoes in storage at 77°F as influenced by treatment with water, or a solution containing 25 μg/ml of gibberellic acid.*

μg/ml of GA	Days after Treatment			
	24	31	38	45
	Per cent	Per cent	Per cent	Per cent
0	11	17	84	95
25	90	96	98	100

lots of ten tubers each. These were immersed on November 10 for 5 minutes in water or in solutions containing 50, 500, or 2000 μg/ml of GA. There were three replications of each treatment. In order to observe the effects of GA on sprouting under likely soil temperature conditions, the potatoes were then stored at 59°F in glass jars. All concentrations of GA were uniformly effective in stimulating sprouting (Figures 1, 2). With solutions containing 50 or 500 μg/ml of GA, sprouts occurred at several eyes on each tuber, whereas potatoes soaked in a solution containing 2000 μg/ml of GA produced sprouts primarily at the apical eyes (Figure 1).

FIGURE 1.—Appearance of White Rose potatoes 8 weeks after they were immersed in solutions containing 0, 50, 500, or 2000 μg/ml of gibberellic acid (stored at 59° F). Notice the branched habit and the greater number of sprouts in the 50, as compared with the 2000 μg/ml treatment.

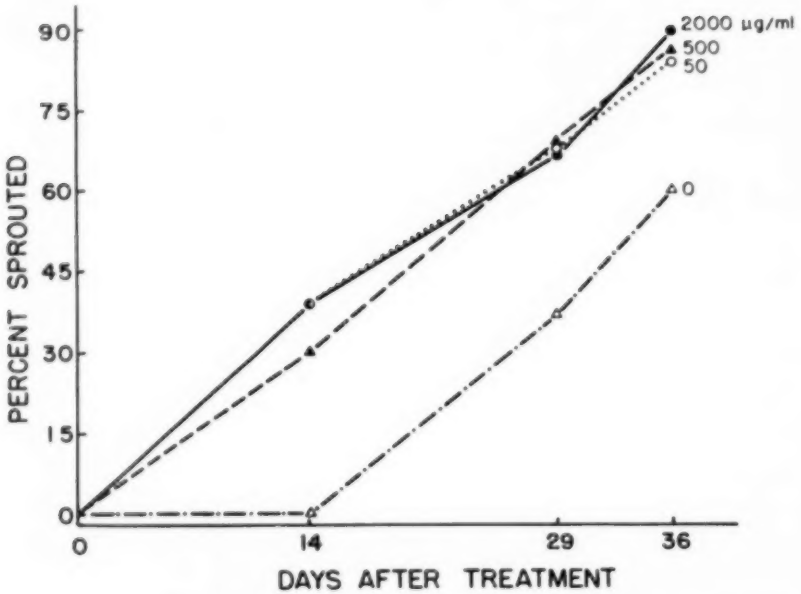

FIGURE 2.—The percentage of White Rose potatoes sprouted at 59° F. as influenced by a 5-minute dip in solutions containing 0, 50, 500, or 2000 µg/ml of gibberellic acid.

Comparative sprout elongation at 77°F was studied with White Rose and Russet Burbank potatoes which immediately after harvest were dipped in water or in solutions containing 25 or 500 µg/ml of GA. Eight weeks later the longest sprout on each tuber was measured. Differential sprout elongation resulted between White Rose and Russet Burbank potatoes treated with a solution of 25 µg/ml of GA (Figure 3). Sprouts of White Rose potatoes elongated more rapidly in response to higher concentrations of GA, whereas significant sprout elongation occurred in the Russet Burbank variety only after treatment with a solution of 500 µg/ml of GA.

B. *Sprouting in Soil under Greenhouse Conditions*: Russet Burbank potatoes were grown in cans of soil in a greenhouse controlled at 65°-70°F following tuber treatment for 5 or 90 minutes in water or in a solution containing 500 µg/ml of GA. As indicated in table 2, immersion in GA as compared with water, for both time intervals, resulted in earlier sprouting and a greater number of sprouted tubers at the end of the experiment. The apparent increase in sprouting of potatoes dipped in water for 5 minutes, as compared with 90 minutes was not consistent with observations in other experiments. Potatoes dipped in GA produced plants which elongated and flowered more rapidly than those dipped in water.

In another experiment the sprouting responses of tubers of the Russet Burbank and Kennebec varieties grown in a soil bench were compared after dipping them for 5 minutes in water or in a solution containing 500

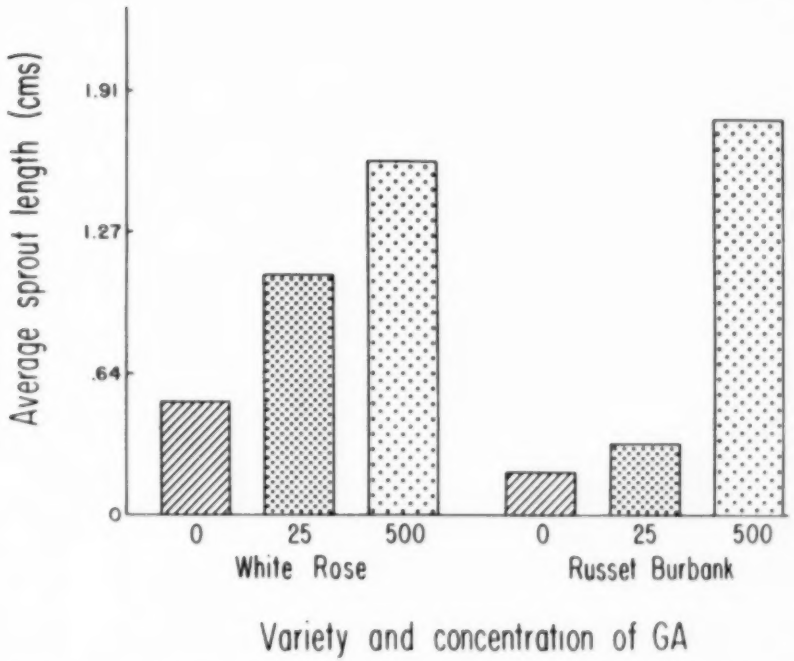

FIGURE 3.—The effect of dipping White Rose and Russet Burbank potatoes in solutions containing 0, 25, and 500 μg/ml of gibberellic acid on the rate of sprout elongation at 77° F. (Measured 8 weeks after treatment.)

TABLE 2.—*Sprouting percentage of Russet Burbank potatoes grown in soil in a 65°-70° F greenhouse after immersion for 5 or 90 minutes in water, or a solution containing 500 μg/ml of gibberellic acid.*

Days after Treatment	Period of Immersion			
	5 Min.		90 Min.	
	0	500	0	500
	Per cent	Per cent	Per cent	Per cent
20	5	35	5	10
25	45	75	15	65
33	55	80	25	80
38	60	80	40	100

μg/ml of GA. Immersion in GA resulted in earlier sprouting of tubers of both varieties (Table 3). In addition, when samples of these same tubers were sprouted in a 50°F storage room the sprouts elongated more rapidly and visible root development was delayed four months; tubers dipped in water produced roots soon after sprouting began. Multiple sprouting (several sprouts at an eye) was characteristic of Kennebec tubers, whereas Russet Burbank potatoes usually produced single, vigorous sprouts at one or more eyes.

The possibility that GA may overcome "chemical dormancy" induced by maleic hydrazide (MH-40) was investigatd. Sixty White Rose and Russet Burbank potatoes, from plants which were sprayed in the field four weeks before harvest with a solution containing 6000 μg/ml of maleic hydrazide, were held at 50°F for three months without producing visible sprouts. These were dipped for 5 minutes in water, or in a solution containing 500 μg/ml of GA, and planted in a soil bench in a greenhouse controlled at 65°-70°F. Six weeks after GA treatment only three potatoes from plants which received maleic hydrazide sprays had sprouted. However, all tubers from unsprayed control plants, irrespective of treatment with GA, sprouted vigorously.

C. *Morphological Considerations*: Brian and coworkers (3) reported that potatoes dipped in GA produced sprouts which branched. Similar effects were noted in the present studies (Figure 1). However, the extent of branching observed differed with variety. Multiple sprouting was common in White Rose and Kennebec potatoes soaked for 5 minutes in a solution containing 500 μg/ml of GA, whereas Russet Burbank potatoes usually produced single sprouts when treated similarly. Sprouts from the White Rose and Kennebec varieties were usually elongated and spindly, whereas those from Russet Burbank potatoes were more vigorous and blocky. Tubers treated with a solution containing 500 μg/ml of GA and planted in soil produced plants that were taller and had longer internodes. They flowered and produced tubers earlier than a comparable lot dipped in water. Similar characteristics have been observed previously with other plant species (2,3,4,7,8,9,10,11). An inward rolling of the young leaves along the central vein was comparable to that observed on tomato leaves after treatment with gibberellic acid (11).

TABLE 3.—*Influence of water or solutions containing 500 μg/ml of gibberellic acid on the sprouting percentage of Kennebec and Russet Burbank potatoes grown in a greenhouse soil bench at 65°-70° F.*

Variety	μg/ml of GA	Days after Treatment				
		43	49	55	63	74
		Per cent	Per cent	Per cent	Per cent	Per cent
Kennebec	0	0	0	15	45	75
	500	70	80	85	90	95
Russet Burbank	0	0	0	13	25	44
	500	10	35	55	75	80

Discussion and Conclusions

Sprouting was hastened by 2 to 3 weeks when newly dug White Rose potatoes were immersed in solutions of GA at concentrations of 25 to 2000 μg/ml. The suggestion by Brian (3) that gibberellic acid may break apical dominance in potatoes was supported by the appearance of sprouts at almost every eye. In the present study a reduction in multiple sprouting at the apical eye of White Rose potatoes resulted from dipping in solutions containing 2000 as compared with 50 or 500 μg/ml of GA. This effect may be similar to one observed in experiments with Earlypak tomato plants (10) which failed to produce axillary vegetative growth (tillers) when their vegetative apices were treated with high concentrations of GA.

Distinct differences between potato varieties in rate of sprouting and sprout elongation resulted from treatment of tubers with GA. White Rose was the most responsive, Russet Burbank the least, with Kennebec intermediate. Possible explanations may be found in the morphological characteristics of these varieties: (a) tubers of the White Rose and Kennebec varieties have slightly deeper eyes than those of Russet Burbank and thus retain the solutions longer; (b) "skinning" and "feathering" of newly dug, immature, White Rose and Kennebec potatoes are common and entry of the chemical may have been facilitated, whereas in Russet Burbank potatoes a thick periderm, relatively impervious to water, forms early in tuber development. Information as to the mode of entry of GA into the tuber may help clarify this point.

A preliminary study suggested that GA treatment was ineffective in breaking the "chemical dormancy" that results from spraying potato plants with solutions containing 6000 μg/ml of maleic hydrazide. However, foliar sprays of MH-40 at concentrations approximating 2500 μg/ml are more commonly recommended. Lower concentrations of MH-40 than used in these tests are, therefore, indicated in future experiments with GA treatment of potatoes.

The inhibition of potato root development in storage resulting from treatment with GA is consistent with that reported for wheat seedlings by Brian *et al.* (1). However, under soil conditions root development occurred in these experiments. This, coupled with greater stem elongation, earlier flowering, and the production of new tubers, suggests that inhibition of rooting might not present a problem when a crop is planted in soil.

The results of these experiments indicate that GA is effective in breaking the dormancy of potatoes. However, they do not necessarily imply that GA, like ethylene chlorohydrin, would be effective as a seed treatment for commercial plantings. Current laboratory and field experiments are designed to evaluate GA as a possible replacement for ethylene chlorohydrin for breaking the rest period of white potatoes.

Summary

A curtailment of the rest period, resulting from treatment with gibberellic acid (GA), of newly dug White Rose, Kennebec, and Russet Burbank potatoes was indicated by a 2- to 3-week acceleration of

sprouting. Five- and 90-minute dip treatments were equally effective. Concentrations of 50, 500, or 2000 μg/ml of GA produced comparable stimulation. Differences among varieties in the percentage of sprouting and in sprout elongation were observed following GA treatment. Preliminary results indicated that GA failed to overcome "chemical dormancy" of tubers from plants which had been sprayed three months earlier with 6000 μg/ml of maleic hydrazide.

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NEWS AND REVIEWS

HOTEL AND MOTEL ACCOMMODATIONS CONVENIENT TO ANNUAL MEETING, PLANT INDUSTRY STATION, BELTSVILLE, MARYLAND

DECEMBER 2-3-4, 1957

EXPLANATION OF SYMBOLS ON ACCOMPANYING MAP

Transportation:

1. Greyhound Bus Line, 1110 New York Avenue, N. W.
   Bus direct to Plant Industry leaves 7:05 a.m., enters grounds and stops in front of Administration Building. Returns 4:35 p.m., from Station to Washington, D. C.

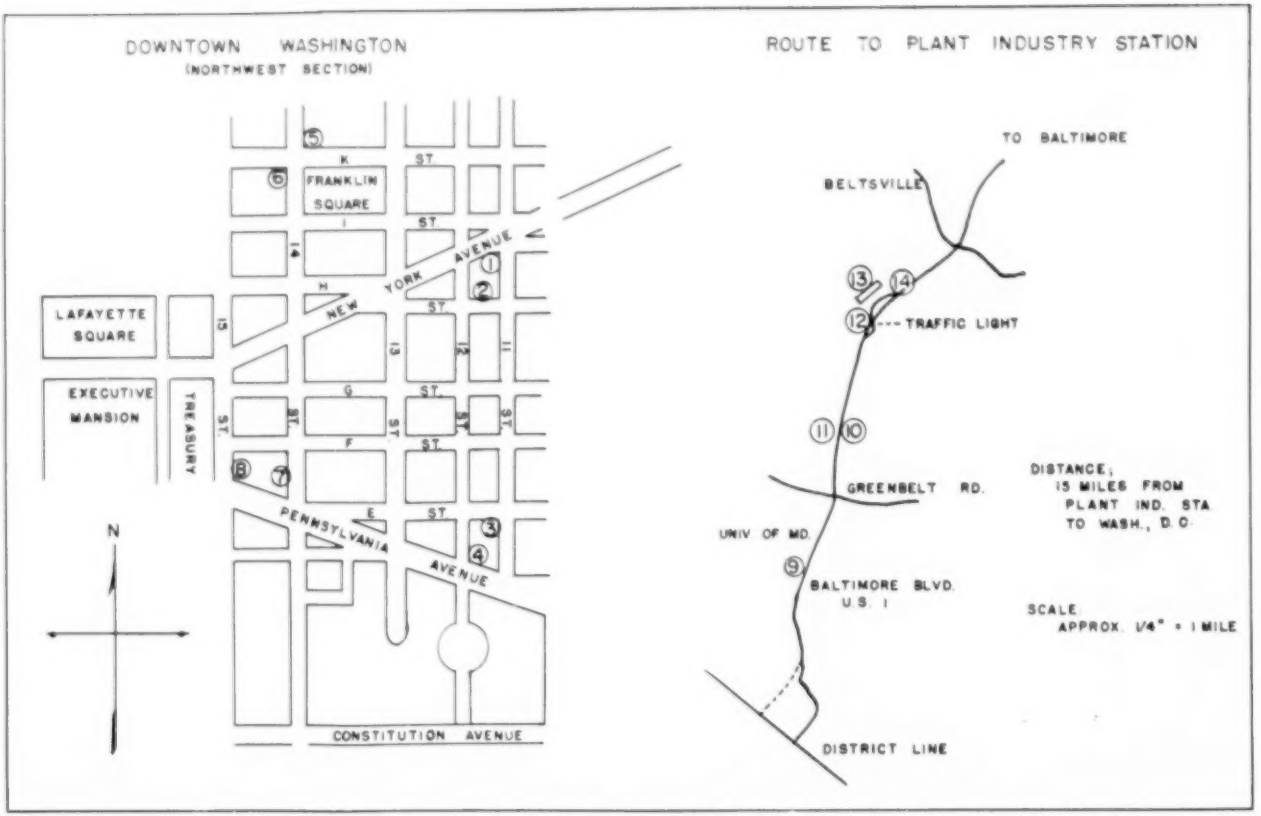
   Baltimore local busses along highway run approximately every half hour (starting on the hour) during the day.

   Ticket: Eighty-five cents (.85) round trip Washington/Berwyn, Maryland. Ten trip commuters' ticket Washington/Berwyn—$2.40.

Hotels in downtown Washington, D. C., conveniently located to the Greyhound Bus Terminal:

Name of Hotel	*Single with Bath*	*Double with Bath*
2. Annapolis Hotel[1] 1111 H St., N.W.	$6.00—$ 9.00	$ 9.00—$11.00 $ 9.50—$12.00 (twin beds)
3. Hotel Harrington 11th & E St., N.W.	$5.50—$ 7.00	$ 8.50—$12.00 $ 9.50—$12.00 (twin beds)
4. Raleigh Hotel 12th & Pennsylvania Ave., N.W.	$6.00—$10.00	$ 9.00—$16.00 $11.00—$16.00 (twin beds)
5. Hamilton Hotel 14th & K Sts., N.W.	$6.00—$ 9.50	$ 8.50—$12.50 $10.00—$12.50 (twin beds)
6. Ambassador Hotel 1412 K St., N.W.	$6.00—$10.00	$ 9.00—$12.00 $10.00—$15.00 (twin beds)
7. Willard Hotel 14th & Pennsylvania Ave., N.W.	$8.00—$12.00	$12.00—$15.00 $13.00—$18.00 (twin beds)
8. Washington Hotel 15th & Washington Ave., N.W.	$7.50—$ 8.50 and $10.00	$12.00—$13.50 and $16.00

[1]This is the most convenient hotel to bus station; situated right in back of bus terminal; ask for rooms on front of building (away from noise of busses).



Map of downtown Washington and route to Plant Industry Station (13), Beltsville, showing location of Hotels and Motels. Symbols are explained on adjacent pages. Take New York Avenue to Route 1 and Beltsville if driving.

Motels in the vicinity of Plant Industry Station, Beltsville, Maryland.
(Prices might be slightly lower in December)

	Rates
9. Lord Calvert Hotel and Cottages 7200 Baltimore Ave., College Park, Md.	$3.00 & $4.00, per person depending on location; winter rates are somewhat cheaper. The foregoing rate is for twin-bedded rooms with bath.
	Single with Bath — *Double with Bath*
10. Royal Pine Motel 913 Baltimore Ave. College Park, Md.	$5.00—$6.00 — $3.50—$4.50 each
11. Hillcrest Motor Court 9122 Baltimore Blvd. College Park, Md.	*Motels*—$4.00 per person, 2 to a room, 2 beds, shower, steam heat and TV. *Hotel*—$3.00 per person, 2 to a room, 2 beds, shower, steam heat and TV. Also have family units.
12. Del Haven White House Motel 10260 Baltimore Ave. College Park, Md.	$5.00—$6.00 $8.00 for 2 (twin beds) Suites of rooms with bath—3 to 4 people to a suite—$3.00 to $4.00 per person. Double beds a little cheaper. Breakfast can be arranged for in advance to be served at any requested time; also can arrange for other meals.
14. Farm Motel 10450 Baltimore Blvd. Beltsville, Md.	Two (2) persons—$6.00 Family units to sleep 6 including 3 double beds with double bath for $14.00. Other units — 2 baths, 2 rooms, 2 double beds and 2 roll-a-way beds, in all to sleep 6, costs $16.00.
13. Meeting Headquarters Administration Building, Plant Industry Station	

Mention you are attending the Potato Association Meeting. Motels may possibly arrange for better rates.

WEED CONTROL CONFERENCE

The Northeastern Weed Control Conference will be held January 8, 9, and 10, 1958, at the Hotel New Yorker, New York, New York. This is the Twelfth Annual Meeting of this Conference which has grown steadily since the original meeting. All those interested in weed control problems are cordially invited.

POTATO RING ROT INFORMATION (AS DETERMINED BY A RECENT SURVEY)[1]

G. H. STARR[2]

In July, 1956, questionnaire forms were prepared and sent to workers in 17 potato-growing states in the United States and to workers in two provinces in Canada. The purpose of this information was to give the writer a better conception of the efforts being put forth on all fronts for the control of bacterial ring rot of potatoes, and particularly those used by commercial growers. This information served as a basis for the article, "Control of Ring Rot" published in the Potato Handbook in the Disease Control Issue for 1957. Although it is impossible to get a true conception of all control activities through the use of a questionnaire, still certain facts or ideas were brought out which may be of interest to potato growers and those who are working with the potato industry. The results are given as briefly as possible in summary form. A list of the 19 persons providing information accompanies this article. Their responses are indicated under the following categories as taken from the questionnaires.

A. IMPORTANCE OF RING ROT

1. Seven workers consider this disease their most important one; 13 consider it as very important; 4, moderately important; and 2, consider it of only slight importance.
2. Diseases listed as being more important than ring rot in certain states were as follows: leafroll, late blight, mosaic, scab, verticillium wilt, wilt, virus, blackleg, western leak, early blight, and haywire.
3. HAS RING ROT DECREASED DURING THE PAST 15 YEARS OR SO?
   Ten workers—yes; six—no; and one, doubtful.
4. "UPS" AND "DOWNS" IN RING ROT PREVALENCE OVER PERIOD OF YEARS? WHY?
   Reasons given for variations:
   a. Carelessness of growers and especially new growers through the lack of sanitary methods.
   b. Variable conditions during last inspection for the detection of ring rot, particularly early maturity and early frosts.
   c. Seed sources and especially seed lots shipped into state—certain varieties are worse than others.
   d. Seasonal spread of disease.
   e. Price situation—when prices are good, more certified seed is used; when poor, own seed is planted.
5. CERTIFIED SEED REJECTED IN 1955
   a. Average acreage rejected in 17 states was 10.3 per cent for 1955, with a variation of none in two states, to a high of 25 per cent in one.
   b. Percentages of fields rejected in one state from 1946 to 1955 in order were: 30.8, 17.9, 16.6, 7.0, 8.3, 14.3, 13.2, 7.1, 8.1, and 5.0.

[1]Accepted for publication June 18, 1957.
[2]Director of Extension, University of Wyoming, Laramie, and formerly Plant Pathologist at University of Wyoming.

c. In another state the percentages of acres rejected from 1940 to 1955 in order were: 0.7, 7.2, 3.4, 4.4, 15.5, 13.1, 23.6, 6.8, 29.1, 8.7, 7.6, 9.3, 9.2, 3.7, 12.6, and 8.1.

d. (Supplementary to Questionnaire) According to a survey made for the years 1940-1951 by H. M. Darling[3], the incidence of ring rot in certified seed was as follows: 1940-1945, 5.4 per cent; 1946-1951, 9.2 per cent; 1940-1951, 7.8 per cent; in 1946 it was 14.8 per cent; whereas in 1947 it was only one-half or 7.3 per cent. The comment made in this article, "There does not appear to be any consecutive series of years in which the disease builds up in prevalence since the survey started in 1940. The shifts that have occurred appear to move more or less at random each year," is quite pertinent.

B. CELLAR SANITATION

1. Fourteen workers stated that sanitation is generally practiced; two that it is not.
2. Chemicals most commonly used for this purpose are copper sulphate, coal tars, formaldehyde, mercury, and chloride compounds.

C. SACK SANITATION (Answers indefinite)

1. Although new bags are required in all states for certified seed, they are required only in five states for commercial potatoes.
2. Used bags are most common, by far.
3. Some states require that used bags coming into the state be disinfested.
4. Most states recognize used bags as a definite factor in the spread of ring rot.

D. TREATMENT OF SEED WITH CHEMICALS

1. Seven workers say it is a common practice; seven others say it is not.
   a. Chemical most commonly used: Semesan Bel.
   b. Others mentioned: Spergon, Phygon, Captan, acid mercury, hot formaldehyde, Streptomycin, Agrimycin, and Dithane.
2. It was pointed out by many that treatment was not particularly for ring rot, but for general purposes.

E. WHOLE SEED *VERSUS* CUT SEED

1. Little information given, but recognized by some that there is less ring rot through the use of whole seed or 1-drops, and more in seed that is cut.
2. The use of cut seed is much more common than whole seed.

F. MOST POPULAR TYPE OF SEED-CUTTING DEVICES, CHEMICALS USED, *ETC.*

1. Hand cutting is most common in seven states.
2. Rotary or mechanical cutters are most common in five states.
3. No disinfectant is used in cutting process in nine states; but is common in five; and very slightly used in three states.

[3]Darling, H. M., 1953, Ring Rot Survey, 1940-1951. Amer. Potato Jour. 30: 184-185.

4. Where disinfectants are used, the following were given in order of popularity: formaldehyde, mercuric chloride, copper sulfate, alcohol, Semesan Bel and chlorine compounds.

G. DISINFESTATION OF PLANTER AND OTHER EQUIPMENT

Treatment of equipment is reported as common in 14 states; but not in three states. Materials used in order of popularity are: copper sulphate, formaldehyde, chlorine compounds, lysol, coal tar, steam, mercury, Roccal, kreso dip, and heat (burner).

H. TYPES OF PLANTERS USED

Picker-type planter is common in all states; the assisted feed is fairly common in three states.

I. CERTIFIED SEED—HOW OFTEN USED?

1. Thirteen workers state that it is commonly used; four say intermittently.
2. Special comments:
   a. "All seed is not more than one to two years from certified."
   b. "Ninety-three per cent of growers use seed not more than one year from certified."
   c. "Ninety-eight per cent use seed not more than one year from certified."

J. ARE DIFFERENT LOTS OF SEED PLANTED IN SEPARATE FIELDS?

Nine workers—yes; four workers—no.

K. IS BEST SEED PLANTED FIRST?

Ten workers—yes; three workers—not always.

L. IS USE OF NEIGHBORS MACHINERY COMMON?

Eight workers—yes; six workers—no.

M. ARE MOST DISEASE-FREE LOTS HARVESTED BEFORE POORER LOTS?

Seven workers—yes; two workers—no; two workers—usually; and three workers—no distinction made.

N. DO GROWERS COMMONLY STORE RING-ROT-INFECTED CROP?

Seventeen workers—yes; one worker—seldom.
Stored over-winter—11 workers—yes; for short periods—six workers—yes.

O. WHAT TYPE OF STORAGE FACILITIES ARE USED?

Private—14 workers; both private and commercial—four workers.

P. HAVE RESISTANT VARIETIES HELPED IN CONTROL OF RING ROT?

1. Comments by certain workers:
   a. Most states haven't used resistant varieties because they are not

adapted, not readily available, dangerous carriers of ring rot and because there are more important considerations in a variety than ring rot resistance.

b. One state uses resistant variety (Teton) where previous ring rot infection existed.

Q. WHAT METHODS HAVE BEEN USED MOST EFFECTIVELY IN CARRYING OUT RECOMMENDATIONS FOR RING ROT CONTROL?

1. In order these are: general meeting and growers meeting; personal visits by specialists and inspectors; letters; mass communications; pamphlets, circulars, *etc.*; field demonstrations and exhibits.
2. The above by: Extension pathologists; Experiment Station pathologists; seed inspectors; potato specialists; county agents; vocational teachers; entomologists; and irrigation specialists.

R. WHAT IS THE ATTITUDE OF COMMERCIAL GROWERS IN SEEKING INFORMATION FOR RING ROT CONTROL?

1. Most workers report that growers are very receptive and cooperative.
2. Special comments from a few workers:
   a. "Only fair—they are not as much afraid as they should be."
   b. "Ring rot occurs on farms of non-cooperative growers."
   c. "All growers try to produce ring-rot-free seed."
   d. "Attitude parallel to disease losses—few have had losses, so few have been active."
   e. "Seed growers have been more conscientious of danger, but many of them apathetic until field is rejected."
   f. "Growers rather passive until disease reaches economic proportions."

S. OTHER FACTORS OR PRACTICES THAT HAVE BEEN IMPROVED THROUGH RING ROT CONTROL PROGRAMS.

1. Special comments:
   a. "Sorting seed while potatoes are dormant."
   b. "Farm sorting of seed — not commercial."
   c. "Carefully selected seed sources have helped."
   d. "Tuber-unit development of our own seed."
   e. "More general use of certified seed."
   f. "Law prohibiting sale of other than certified seed."
   g. "Avoidance of community or commercial type storage seed farm."
   h. "Seed examined carefully on receipt and rejected if ring rot is found."
   i. "Use of locally-grown seed."
   j. "Securing new seed and thorough disinfection."
   k. "Constant vigilance on part of plant breeders and potato shippers."
   l. "Isolation of growers is an important factor."
   m. "Discouraging the use of machinery exchange."
   n. "Supplying itinerant harvesting crews with clean disinfected clothing."

o. "Prohibiting foreign equipment from being brought into cellars without previous disinfection."
p. "Not permitting buyers to use own pocket knives for cutting seed in storage."

T. GENERAL COMMENTS (By Author)

1. It is apparent that ring rot prevalence has varied considerably from year to year without evidence of consecutive build-up over a period of years. Certain reasons have been suggested by various workers for this variation; no doubt there are others than those listed.
2. The various steps of potato production, as listed in the questionnaire should serve to remind us that contamination of seed with ring-rot bacteria can occur on every turn; infection can be increased greatly in a lot of seed in a year's time. The use of whole seed (one-drops) will help.
3. If seed is to be kept free from ring rot, all known control measures will have to be followed. It will be useless to follow most of the practices known to be sound and then let down in even one practice which permits infection or spread of infection as the case may be.
4. It is suggested that the article by H. M. Darling, already referred to, and the recent article on "Disease Control" in the Potato Handbook for 1957 be read again. Many other articles and types of information are available locally and should be followed closely.

List of Persons Providing Information

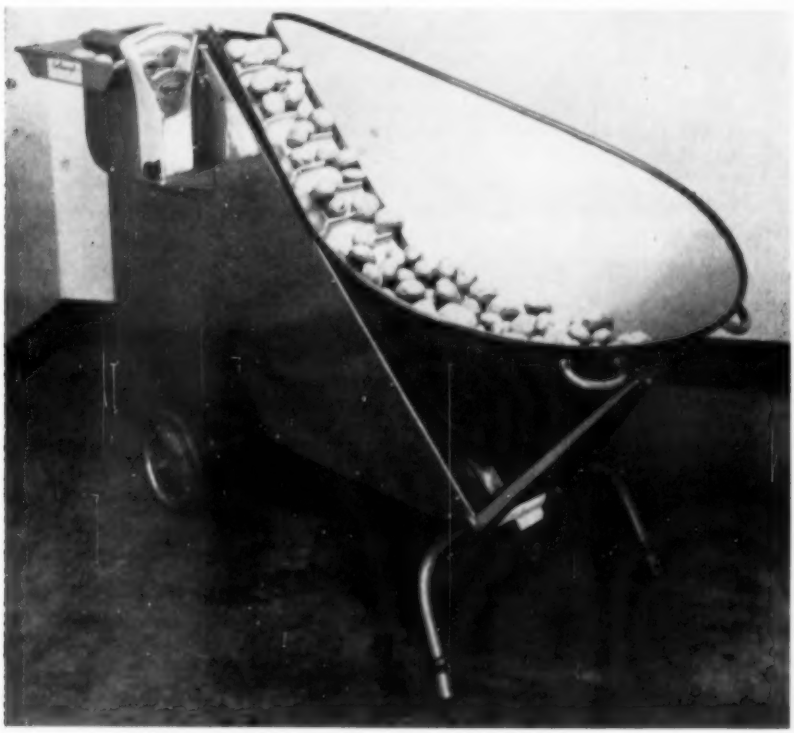
1. Beverly, Verne and Reiner Bonde, Formerly County Agent, Presque Isle and Plant Pathologist, University of Maine, Orono.
2. Blackburn, T. C., Crop Improvement Association, and J. S. Gregory, University of Idaho, Moscow.
3. Campbell, John C., Associate Plant Pathologist, Rutgers University, New Brunswick, New Jersey.
4. Clarkson, S. F., Director, Plant Protection and Promotion Branch, Fredericton, New Brunswick, Canada.
5. Darling, Henry M., Seed Certification, University of Wisconsin, Madison.
6. Fernow, K. H., and R. S. Dickey, Extension Plant Pathologists, New York State College, Ithaca.
7. Frutchey, C. W., Seed Certification, Colorado State University, Ft. Collins.
8. Hastings, R. C., State Seed Commissioner, Fargo, North Dakota.
9. Hoff, Philip A., Certification Manager, Alliance, Nebraska.
10. McLaughlin, F. W., Seed Certification, and L. W. Nielson, Department of Plant Pathology, North Carolina State College, Raleigh.
11. Moore H. C., Potato Certification, Michigan State University, East Lansing.
12. Noonan, John, Secretary, Potato Growers Association, Watertown, South Dakota.
13. Rincker, Clarence, Seed Certification Manager, University of Wyoming, Laramie.
14. Scannell, J. W., Department of Agriculture, Plant Protection Division, Ottawa, Ontario, Canada.
15. Scott, John W., Department of Agriculture, Montpelier, Vermont.
16. Stoker, Golden L., Utah Crop Improvement Association, Logan.
17. Tolaas, A. G., Seed Potato Certification, University of Minnesota, St. Paul 1, Minn.
18. Yager, Leonard A., Extension Horticulturist, Montana State College, Bozeman.
19. Yount, William L., Seed Certification, Department of Agriculture, Harrisburg, Pennsylvania.

NEW PRODUCE BAGGER

A new Produce Bagging Machine, known as the ROLLAWEIGH, has been announced by THE EXACT WEIGHT SCALE COMPANY, Columbus, Ohio. This machine has been under extensive field trial operation by a number of produce packers and chain stores during the past year.

The ROLLAWEIGH Bagger is designed for pre-packaging potatoes, onions, yams, sweet potatoes, oranges, lemons and nuts in the shell.

The EXACT WEIGHT ROLLAWEIGH is designed for fast weighing and bagging of almost any kind of produce — into any type of bag. No adapters are needed. Capacity up to 15 lbs., and weight change over can be made in 30 seconds, by merely changing the counterweights.



Compactly built, it is easily moved from one location to another. It is fully enclosed, and sturdily built for trouble free performance under all normal conditions.

This machine is a continuous-flow, automatic weigh-bagger, incorporating several unique features such as the conveyor belt which is mounted on a high-quality, proven scale which accurately and rapidly net weighs and delivers many kinds of produce to any type of container. The scale is expressly designed for this modern belt-weigher machine. The manu-

facturer states this machine is carefully constructed to measure up to the highest standards maintained on all EXACT WEIGHT SCALES. The scale component conforms to the Federal Weights & Measures specifications and requirements for this class of weighing equipment.

Produce is loaded into the open hopper at the rear of the unit. It is gently carried up from the hopper (by a rubber belt with staggered rubber flights for singulated accurate feeding) to a short travel conveyor which travels across the weight platter. Product feeding is automatically cut off as correct weight is reached. Produce flows out as the operator slips the bag in position and depresses the delivery scoop. The cycle repeats when the scoop is released. For further information, write today for your copy of Form 3306. Mention the American Potato Journal.

BOOK REVIEW

THE MULCHING OF VEGETABLES, Technical Communication No. 24., Commonwealth Bureau of Horticulture and Plantation Crops. By Patricia Rowe Dutton. Commonwealth Agricultural Bureau, Farnham Royal, Bucks, England, pp. 169. Twenty schillings. (U.S.A. & Canada $2.80)

The author has reviewed over 350 popular and scientific articles from all over the world on the use of various types of mulches on many vegetable crops. She does not try to draw conclusions as to the merits of mulches but presents the often conflicting conclusions of the research workers in a manner that makes the work of value to the commercial and home garden vegetable grower as well as the research specialist.

The introduction discusses the general nature and function of mulches and succeeding chapters are devoted to the effect of mulches on various vegetable crops including a very complete review of the work on white potatoes. The effect of mulches on diseases and insects is also discussed.

The book should be of value to those interested in research on the subject and to the vegetable gardener. Practical value for the commercial vegetable grower is limited because of the economic problems involved.

JOHN C. CAMPBELL, *Assoc. Plant Pathologist*
Rutgers University

IX INTERNATIONAL BOTANICAL CONGRESS

The Ninth International Botanical Congress will be held in Montreal, Canada, from August 19 to 29, 1959, at McGill University and the University of Montreal. The program will include papers and symposia related to all branches of pure and applied botany. A first circular giving information on program, excursions, accommodations, and other detail will be available early in 1958. This circular and subsequent circulars including application forms will be sent only to those who write to the Secretary-General asking to be placed on the Congress mailing list:

Dr. C. Frankton, Secretary-General
IX International Botanical Congress
Science Service Building
Ottawa, Ontario, Canada.

FUNGICIDE REPORT

"Results of 1956 Fungicide Tests" reprinted from a series of articles appearing in *Agricultural Chemicals*, February through August, may be purchased in bound and covered form for $1.00 per copy by sending orders, with remittance, to Dr. A. B. Groves, Department of Plant Pathology, Virginia Agricultural Experiment Station, R. R. 3, Winchester, Virginia. The publication of these results is under the sponsorship of the American Phytopathological Society. It is a continuation of the publication of results formerly provided through a Supplement of the Plant Disease Reporter, Plant Disease Epidemics and Identification Section, United States Department of Agriculture.

The Temporary Advisory Committee on Collecting and Disseminating Data on New Fungicide Tests of the American Phytopathological Society arranged for the recent publication of data and the continuation of a program for annual publications of Fungicide Test Results in the future. Dr. A. B. Groves, Department of Plant Pathology, Virginia Agricultural Experiment Station, Winchester, Virginia, will be in charge of this project during the current year.

WANTED

We are in need of certain volumes of the American Potato Journal. If you are not using your old Journals why not sell them? We will pay the prices noted below for the issues listed. Look through your Journals and send any of the desired copies to John C. Campbell, Treasurer, Potato Association of America, New Brunswick, N. J. Prompt payment will follow.

Volume 1, Nos. 1 and 2 @ 50¢; others @ 75¢. Complete volume $9.00.
Volume 2, No. 6 @ 50¢; others @ 75¢. Complete volume $9.00.
Volume 3, All Nos. @ 75¢; Complete volume $9.00.
Volume 4, All Nos. @ 75¢. Complete volume $9.00.
Volume 5, All Nos. @ 75¢. Complete volume $9.00.
Volume 6, Nos. 4, 6 and 10 @ 75¢; others @ 50¢. Complete volume $7.00.
Volume 7, All Nos. @ 75¢; Complete volume $9.00.
Volume 8, Nos. 1, 3, 8, 9 and 11 @ 50¢; others @ 75¢; complete $8.00.
Volume 9, No. 2 @ 75¢; Complete volume $4.00.
Volume 10, Nos. 1, 4, 8, 12 @ 75¢; Complete volume $$4.00.
Volume 11, No. 4 @ $1.00; Complete volume $3.00.
Volume 12, No. 2 @ $1.00; Complete volume $3.00.
Volume 13, No. 1 @ 50¢; Complete volume $3.00.
Volume 14, No. 1 @ $1.00. Complete volume $3.00.
Volume 17, No. 3 @ $1.00. Complete volume $$3.00.
Volume 20, No. 2 @ $1.00; Complete volume $3.00.
Volume 23, Nos. 1 and 3 @ $1.00; Complete volume $4.00.
Volume 26, No. 2 @ $1.00; Complete volume $4.00.